able to interpret a section correctly and to know when there is a glaring fault in his technique.—W. J. G. LAND.

Illustrations.—A series of lectures dealing with the illustration of botanical papers was delivered at the University College, London, in 1913, by T. G. HILL. In response to various requests, these lectures are now published in book form.[10] The various forms of intaglio, plane surface, and relief printing are described, and their limitations noted. Suggestions are given for the preparation of copy suited to the various types of reproduction. The descriptions of processes are interesting, and, combined with the practical hints, should enable investigators to furnish more effective copy. There is no effort to give instruction in drawing.—C. J. CHAMBERLAIN.

North American Flora.—The third part of Vol. 17 continues the presentation of the Poaceae, and includes the genus *Panicum* by HITCHCOCK,[11] who recognizes 211 species distributed among 46 tribes. No new species are described, but it is interesting to note that HITCHCOCK's name is associated with 32 of the species. Other diligent students of the species have been NASH (30 species), SCRIBNER (25 species), and ASHE (16 species).—J. M. C.

NOTES FOR STUDENTS

Anthocyanins.—WILLSTÄTTER[12] and his students have made an extensive study of the anthocyanins of various flowers and fruits. The findings are certain to prove of great importance to plant workers, especially breeders and physiologists. The work puts this previously little understood group of plant pigments among those most thoroughly worked. All such matters as methods of extraction, purification, and quantitative estimation, general chemical constitution, general chemical characters, empirical and structural formulae, and

[10] HILL, T. G., The essentials of illustration. 8vo. pp. xii+95. London: Wesley & Son. 1915.

[11] North American Flora **17**:part 3. pp. 197–288. Poales: Poaceae (pars), by G. V. NASH and A. S. HITCHCOCK. New York Botanical Garden. 1915.

[12] WILLSTÄTTER, R., Über Pflanzenfarbstoffe. Ber. Chem. Gesells. **47**:2831–2874. 1915; WILLSTÄTTER, R., and NOLAN, T. J., II. Über den Farbstoff der Rose. Ann. Chem. **408**:1–14. 1914; WILLSTÄTTER, R., and MALLISON, H., III. Über den Farbstoff der Preiselbeere, *ibid.* 15–41; WILLSTÄTTER, R., and BOLTON, K., IV. Über den Farbstoff der Scharlachpelargonie, *ibid.* 42–61; WILLSTÄTTER, R., and MIEG, W., V. Über ein Anthocyan des Rittersporns, *ibid.* 61–82; WILLSTÄTTER, R., and ZOLLINGER, E. H., VI. Über die Farbstoffe des Weintraube und der Heidelbeere, *ibid.* 83–109; WILLSTÄTTER, R., and MARTIN, K., VII. Über den Farbstoff der *Althaea rosea, ibid.* 110–112; WILLSTÄTTER, R., and MIEG, W., VIII. Über den Farbstoff die wilder Malve, *ibid.* 122–135; WILLSTÄTTER, R., and NOLAN, T. J., IX. Über den Farbstoff die Päonie, *ibid.* 136–146; WILLSTÄTTER, R., and MALLISON, H., X. Über Varationen der Blütenfarben, *ibid.* 147.

the cause of variation in the color of flowers bearing these pigments, have been established or made very probable.

The anthocyanins are characterized as nitrogen-free substances of amphoteric nature. Their strong basic character is due to the fact that with acids they form oxonium salts with tetravalent oxygen. This character forms the best basis for their isolation and purification, since on this basis they form good crystalline bodies with various organic and inorganic acids. The chlorides were most used. The acid character of the anthocyanins is due to their polyphenolic nature. This was formerly used as the basis for isolation by the precipitation as lead salts, but it is undesirable, since many other substances fall out with the pigments. The acid salts are red, the neutral anthocyanins violet, and the alkali salts (for such anthocyanins as form them) are blue. In neutral and still more frequently in alkaline condition the anthocyanins become colorless. This is due to an isomerization, and not to a reduction, as is generally assumed. This is suggestive in explaining the loss of color by flowers under certain conditions.[13] Upon acidulation the color returns. In plants the anthocyanins exist entirely or nearly so as glucosides. Brief heating of the anthocyanins with 20 per cent HCl splits them into glucose and the corresponding anthocyanidins. The following are some of the studied anthocyanins and their splitting products.

Anthocyanin	Isolated from	Anthocyanidin +
Cyanin ($C_{27}H_{31}O_{16}Cl\ 2\frac{1}{2}H_2O$)	Centaurea cyanus	Cyanidin ($C_{15}H_{11}O_6Cl$ + 2 glucose)
Pelargonin ($C_{27}H_{31}O_{15}Cl\ 4H_2O$)	Pelargonium zonale	Pelargonidin ($C_{15}H_{11}O_5Cl$ + 2 glucose)
Delphinin ($C_{41}H_{39}O_{21}Cl\ 12H_2O$)	Delphinium consolida	Delphinidin ($C_{15}H_{11}O_7Cl$ + 2 glucose + 2 p oxybenzoic acid)
Önin ($C_{23}H_{25}O_{12}Cl\ 4H_2O$)	Deep colored wine grape	Önidin* ($C_{17}H_{15}O_7Cl$ + 1 glucose)
Malvin ($C_{29}H_{35}O_{17}Cl\ 8H_2O$)	Wood malva	Malvidin* ($C_{17}H_{15}O_7Cl$ + 2 glucose)

* Önidin and malvidin are dimethyl ethers of delphinidin.

Several physical constants (crystal shape and color, melting or decomposition points, solubility in various reagents, isomerization with soda, and reaction with iron chloride and iron picrate) of these anthocyanins and anthocyanidins have been tabulated. These, with the methods of extraction and purification, put significant methods into the hands of plant breeders of moderate chemical training.

Variations in the color of flowers bearing these pigments are due to one or more of four causes: (1) various anthocyanins in the same flower or species; (2) great variation in the anthocyanin content; (3) chemical reaction of the

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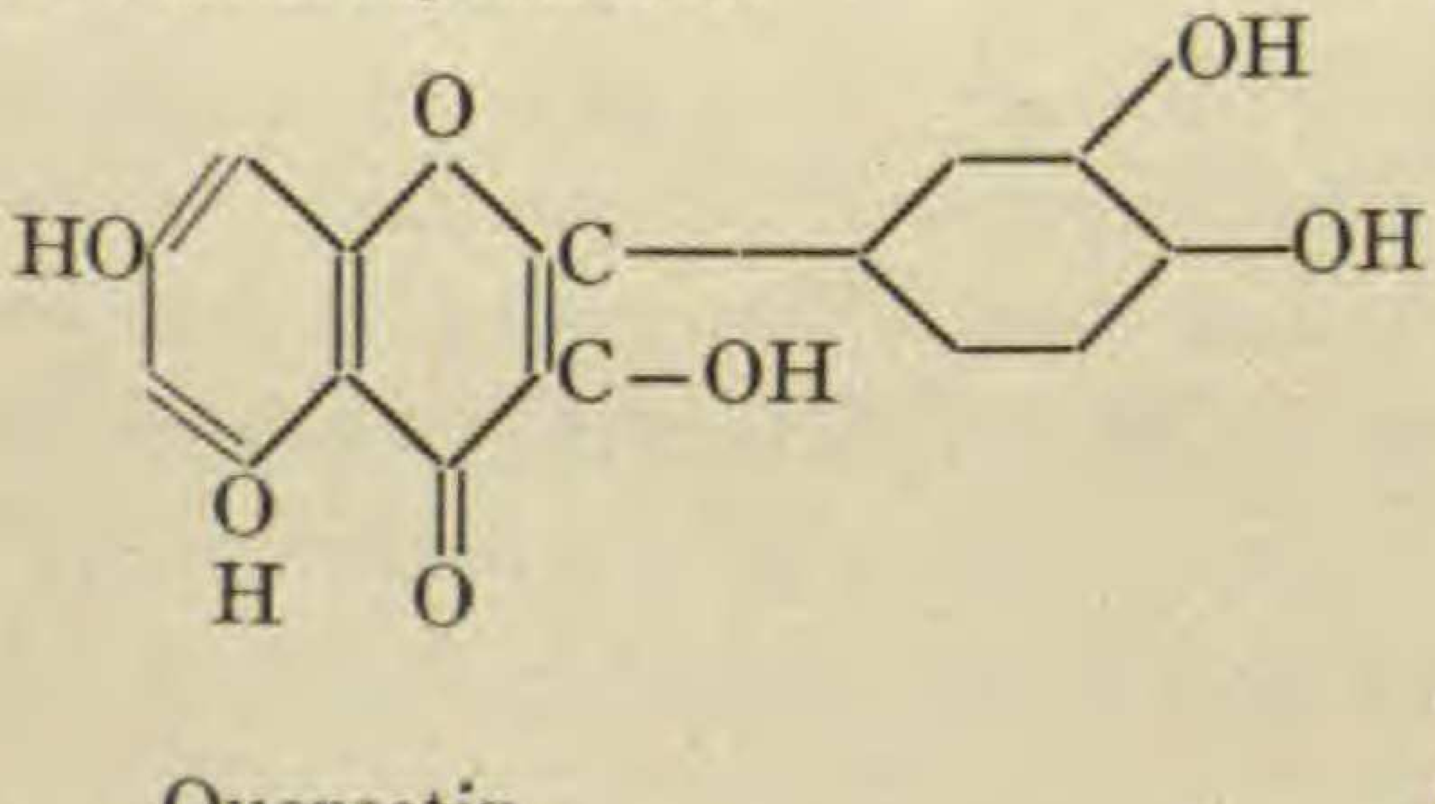
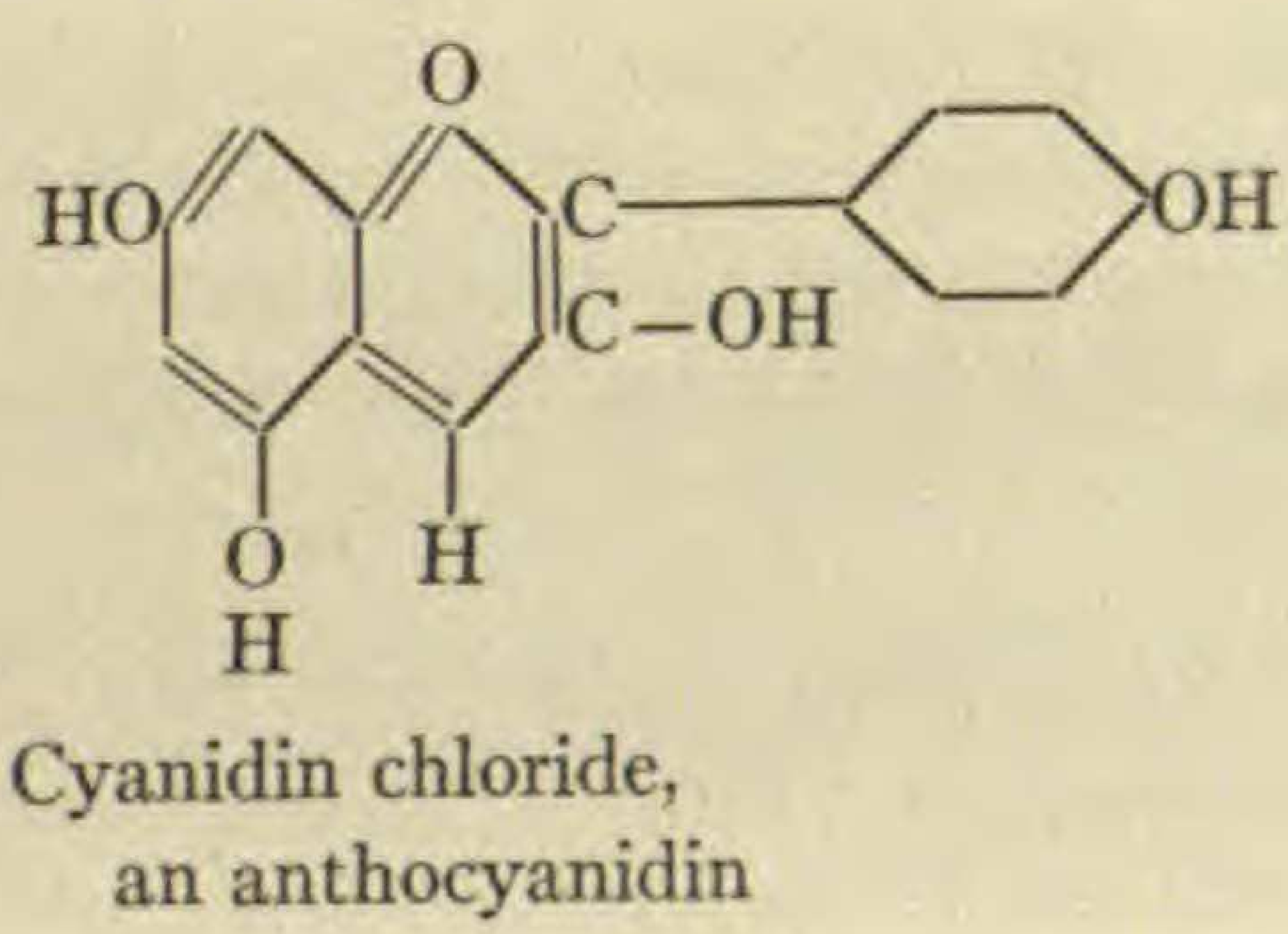
[13] FITTING, H., Über eigenartige Farbanderungen von Blüten und Blütenfarbstoffen. Zeitschr. Bot. 4:81–106. 1912.

cells; (4) mixtures with yellow pigments. The following are a few illustrations of the significance of these factors: (1) The dark purple-red flowers of *Centaurea cyanus* bear cyanin, the rose-red flowers pelargonin; a violet-red variety of *Pelargonium* bore mainly cyanin with a slight amount of pelargonin. This is said to be the first plant in which a mixture of anthocyanins was found in the same flower. (2) The bright red and dark red garden rose both bear cyanin with a great difference in concentration. The flower of the field *Centaurea cyanus* contains 0.65–0.70 per cent dry weight of alkaline cyanin, while a dark purple double garden variety bears 13–14 per cent. (3) Blue flowers of *Centaurea* contain potassium salts of cyanin, violet flowers of *Delphinium* neutral delphinin, and scarlet flowers of *Pelargonium* tartrate of the anthocyanin. (4) The following yellow pigments may act with anthocyanins in determining the flower color: (*a*) neutral carotinoids, carotin and xanthophyll; (*b*) the glucosidic flavone pigments; (*c*) the little-known anthochlors of the cell sap. It is found that the green color shown by a crude extract of anthocyanin of alkaline reaction results from the mixture of the blue of the alkali salts of the anthocyanin and a yellow pigment. Some of the flavone dyes, also the pseudobases of anthocyanin, are almost colorless in neutral and acid solutions, but intensely yellow in alkaline solution. This is suggestive to breeders dealing with yellow and white flowers.

We are coming to know something of the substances from which the anthocyanins originate, and the reactions by which they are produced. There are many facts to suggest a close relationship between the yellow pigments of plants of the favone or flavonol type and the anthocyanins. COMBES[14] has made probable that this is a genetic relationship in obtaining anthocyanin by the reduction of yellow pigments extracted from plants; and EVEREST[15] brings still more evidence for the view that the anthocyanins originate from the flavonol yellow pigments by a simple process of reduction. He has produced anthocyanins by reducing flavonol glucosides and similarly anthocyanidins by reducing the sugar-free flavonol derivatives. The following formulae express his idea of the relation between the yellow flavonols and the chlorides of the anthocyanidins:



Quercetin,
a flavonol derivative



Cyanidin chloride,
an anthocyanidin

[14] Compt. Rend. Acad. Sci. Paris **158**:272–274. 1914; Ber. Deutsch Bot. Gesells. **31**:570–578. 1914.

[15] Jour. Genetics **4**:361–367. 1915.

These formulae will also serve to give an idea of the constitution of the anthocyanidins. The flavonols and flavones are well known yellow pigments of plants. Our thorough knowledge of the chemistry of these pigments is partly due to their extensive use in the dyeing industry. WHELDALE[16] has suggested that anthocyanins originate from the flavonol glucosidic pigments by a process of hydrolysis followed by oxidation, and she questions EVEREST'S ideas as set forth above, so far as they apply to the origin of anthocyanins in plants, since the drastic reagents used by EVEREST are not available for the plant. It would seem that her protest is rather poorly grounded.

Almost every point established concerning the anthocyanins is of great immediate significance to plant breeders and physiologists. WILLSTÄTTER and his students have done much to put our knowledge of this group of pigments on solid foundations, as they previously did for the pigments of the chloroplast.—WM. CROCKER.

Anatomy of Isoetes.—LANG,[17] in continuing his studies of *Isoetes*, has analyzed the stele of *I. lacustris*, with the help of apical development. The contradictory interpretations of the stem of *Isoetes* have arisen from complications due to the occurrence of crowded leaves upon a very slightly elongating axis, accompanied by the continued growth of the cortex. The summary of the analysis is as follows, proceeding from within outward: (1) central colnmn of primary xylem (the strictly cauline region of the stem); (2) peripheral zone of xylem, consisting of bases of leaf traces connected with the central cylinder and radially arranged xylem between the entering leaf traces; (3) parenchymatous xylem sheath, continuous with similar region in leaf trace; (4) primary phloem, continuous with phloem of leaf trace; (5) secondary prismatic tissue, consisting of tracheids, sieve tubes, or parenchyma; (6) meristen of secondary prismatic tissue; (7) cortical tissue. LANG states that such an analysis of the stele of *Isoetes* "not only affords points for comparison with the Lepidodendreae, but promises to be of interest from the standpoint of general stelar morphology."—J. M. C.

Espeletia.—This is a genus of the Asteraceae, restricted so far as known to the high cordilleras of Colombia and Venezuela. The genus is among the most conspicuous of the composites, the leaves and inflorescences in most of the species being closely invested by long wool. The genus has just been revised by STANDLEY,[18] who recognizes 17 species, 6 of which are described as new.—J. M. C.

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[16] Jour. Genetics **4**:369–376. 1915.

[17] LANG, WILLIAM H., Studies in the morphology of *Isoetes*. II. The analysis of the stele of the shoot of *Isoetes lacustris* in the light of mature structure and apical development. Mem. and Proc. Manchester Lit. and Phil. Soc. **59**:29–56. *pls. 4. figs. 7.* 1915.

[18] STANDLEY, PAUL C., The genus *Espeletia*. Amer. Jour. Bot. **2**:468–485. *figs. 6.* 1915.